PB-216 242

STATISTICAL EVALUATION OF PACKING HOUSE WASTE DATA

Conrad P. Straub

Oak Ridge National Laboratory
Oak Ridge, Tennessee

1953

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 216 242

LIBRARY
ENVIRONMENTAL HEALTH CENTER
CINCINNATI, OHIO

STATISTICAL EVALUATION OF PACKING HOUSE WASTE DATA*

By

Conrad P. Straub, Senior Sanitary Engineer, Environmental Health Center, U.S. Public Health Service, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

*Presented at the 8th Industrial Waste Conference, Purdue University, Lafayette, Indiana, May 5, 1953.

Some years ago, in studying the published data relating to the characteristics of packing house and slaughterhouse wastes, the writer was impressed with the variability of the reported values. In an attempt to group the data from the many plants, and to obtain a more reliable estimate of the normal range in values that might be expected in the volume, biochemical oxygen demand (BOD), suspended solids (SS), total nitrogen, grease, and population equivalent (PE) of the wastes, these data have been analyzed by statistical methods.

According to Peters and Van Voorhis(1), in giving an adequate description of a mass of quantitative data, one must do one or another, or several, of the following things: 1) indicate the general size of the variables - mean, mode, median, or other index of "central tendency"; 2) indicate the spread of the variables; 3) show the shape of the distribution; 4) show the relation of two or more sets of variables to each other; and 5) indicate dependability of the generalizations.

Methods that may be employed in evaluating the above criteria have been described by Fair(2) and Velz(3). In recent years, several papers have been published in which similar procedures were used in the analysis

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

of specific waste materials. For example, Weston, Merman, and DeMann[4][5] utilized these techniques in evaluating the probability of occurrence of different characteristics of oil waste waters, Dougherty[6] for defining the characteristics of food processing wastes, and Eckenfelder[7] for describing the characteristics of tomato and apple wastes. In the above studies, statistical procedures were used to evaluate the wastes from specific plant investigations. With the exception of these studies, the data reported in the literature are generally limited to a listing of the mean or range without any statement of the statistical variation of the data.

The evaluation of packing house waste data, which is to be reported, includes data from many plants, and is believed to be the first extensive statistical evaluation of this type for these waste materials.

Procedure

To evaluate any of the criteria given by Peters and Van Voorhis[1] the graphical procedures described by Fair[2] and Velz[3] may be employed along with simple analytical methods. The methods to be used in preparing the probability plots have been spelled out by Thomas[8] and Velz[3] and consist of arraying the data under consideration in ascending order of magnitude and assigning a plotting position to each value in the array. The plotting position is calculated by means of the expression $\frac{m}{n+1}$, where m is the serial number in ascending order of magnitude and n is the total number of measured or observed values to be plotted. Thomas[8] has given a mathematical derivation for this expression. To simplify the plotting, probability papers designed by Hazen are used. If the plot is made on arithmetic probability paper and the array follows a straight line,

the distribution is said to be normal, i.e., the mean, median, and mode are all coincident and are found by noting the point where the curve crosses the 50 per cent probability line. If the distribution on arithmetic probability paper is concave, it may be possible to normalize the distribution by plotting the logarithms of the values. Log probability paper may be employed to obviate the need for plotting the logarithms of the values.

The standard deviation may be determined from the arithmetically normal curves directly, by noting the mean plus or minus the standard deviation values which correspond to the points of intersection of the curve with the 15.87 and 84.13 per cent probability lines and subtracting the mean values therefrom.* In a similar manner the range included by the mean plus or minus twice the standard deviation may be found from the values at the intersection of the curve and the 2.27 and 97.73 per cent probability lines.*

To determine the difference between two distributions, procedures outlined by Velz[3], or given in any textbook on statistical methods, may be used. These include the calculation of the standard error of the

---

* In the case of the logarithmically normal curve, the same comments hold true if the logarithms of the individual values are plotted. If the numbers themselves are plotted on logarithmic scales, the procedure involved is slightly different. The values corresponding to the points of intersection with the 15.87 and 84.13 per cent probability lines are read from the curve as are those corresponding to the 2.27 and 97.73 per cent probability lines. From the square root of the ratio of the 84.13 to the 15.87 per cent values the logarithmic standard deviation is calculated and this represents 68 per cent of the range in values. The 95 per cent values are found by multiplying or dividing the M_g value by $(s_g)^2$.

mean ($SE_{mean} = \frac{s}{\sqrt{n}}$), the standard error of the difference of two means ($SE_{diff.} = \sqrt{(SE_{mean_1})^2 + (SE_{mean_2})^2}$), the difference between the two means, Student's "t", and from this, the determination of the significance by comparison with values in the "t" tables corresponding to a given n and probability value.

Waste Volume Data

One of the first points of interest in a study of any waste problem is some indication of the volume of waste produced and whether there is any relationship between waste volume and amount of product processed. Data pertaining to the volume of waste produced are plotted in Figure 1. Except for the data reported by Hill[9], indicated by the three lines in the figure, little data are available which will permit a plot of the volume of waste produced per unit of kill vs the kill per day. If these data (exclusive of the values reported by Hill) are considered, it will be seen that there is little relation between the two parameters. If correlation is ascribed to these few values, the trend indicated by the data appears to be contrary to that which would be expected, since under usual conditions, one would assume that the volume of waste per unit of kill would decrease as the number of animals slaughtered increased. In the case of the Austin data[9], there is a very definite relationship between the daily kill and the volume of waste produced, and the trend is in the direction that would be expected - the volume of waste decreases with an increase in the weight of slaughter.

In this same figure (Figure 1) Hill's data showing the variation in waste volume with the season of the year have been reproduced and compared with data reported for Austin, Minnesota[9]. In plotting the Austin data,

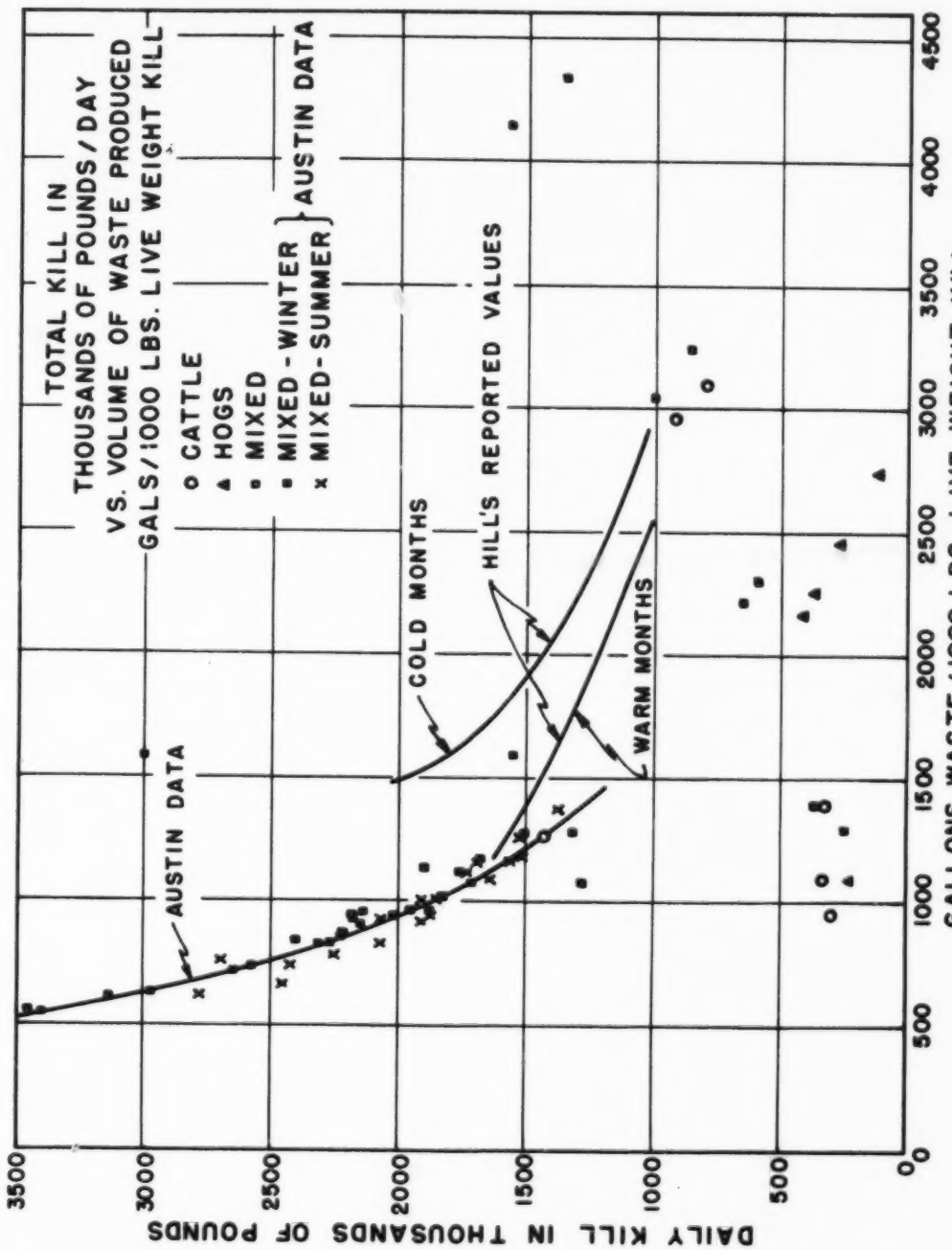

Figure 1 - Relation between daily kill in thousands of pounds
vs volume of waste produced/1,000 lbs live weight kill.

different symbols were used for the winter (October through March) and summer (April through September) values. There appear to be little, if any, seasonal differences in these data. Actually, statistical evaluation has shown practically no difference in the overall summer or winter values. Hill's curves showing higher waste volumes in winter than in summer are very significant, because the numbers of animals slaughtered during the winter months are generally somewhat higher than during the summer months. Increased slaughter would be associated, in all probability, with smaller unit waste volumes. As a consequence, there must be other factors responsible for the greater usage of water during the cold months as reported by Hill. It would be of considerable interest to delve into plant practices and ferret out the reason for the conditions reported.

To determine the nature of the distribution of the volumes of waste produced in gallons per 1,000 pounds live weight kill (gal/1,000 lbs. LWK), the unsorted data* were arrayed in increasing order of magnitude and plotted on log probability paper. As indicated in Figure 2 the packing house waste volume data separate into two groupings denoted by curves (a) and (b), which divide at a waste flow of about 2,000 gal/1,000 lbs. LWK. (Curves (a) and (b) have been composited by eye and represented by curve (c)). Because of this division of curves (a) and (b), they were replotted considering each portion as a separate distribution shown by curves (e) and (d), respectively. The lower group of data, represented by curve (a), have a

*Unsorted in the sense that hog, cattle, and mixed slaughter values were all compared together and that no attempt was made to group data that represented daily, weekly, monthly, or annual averages, or even averages of data from several plants.

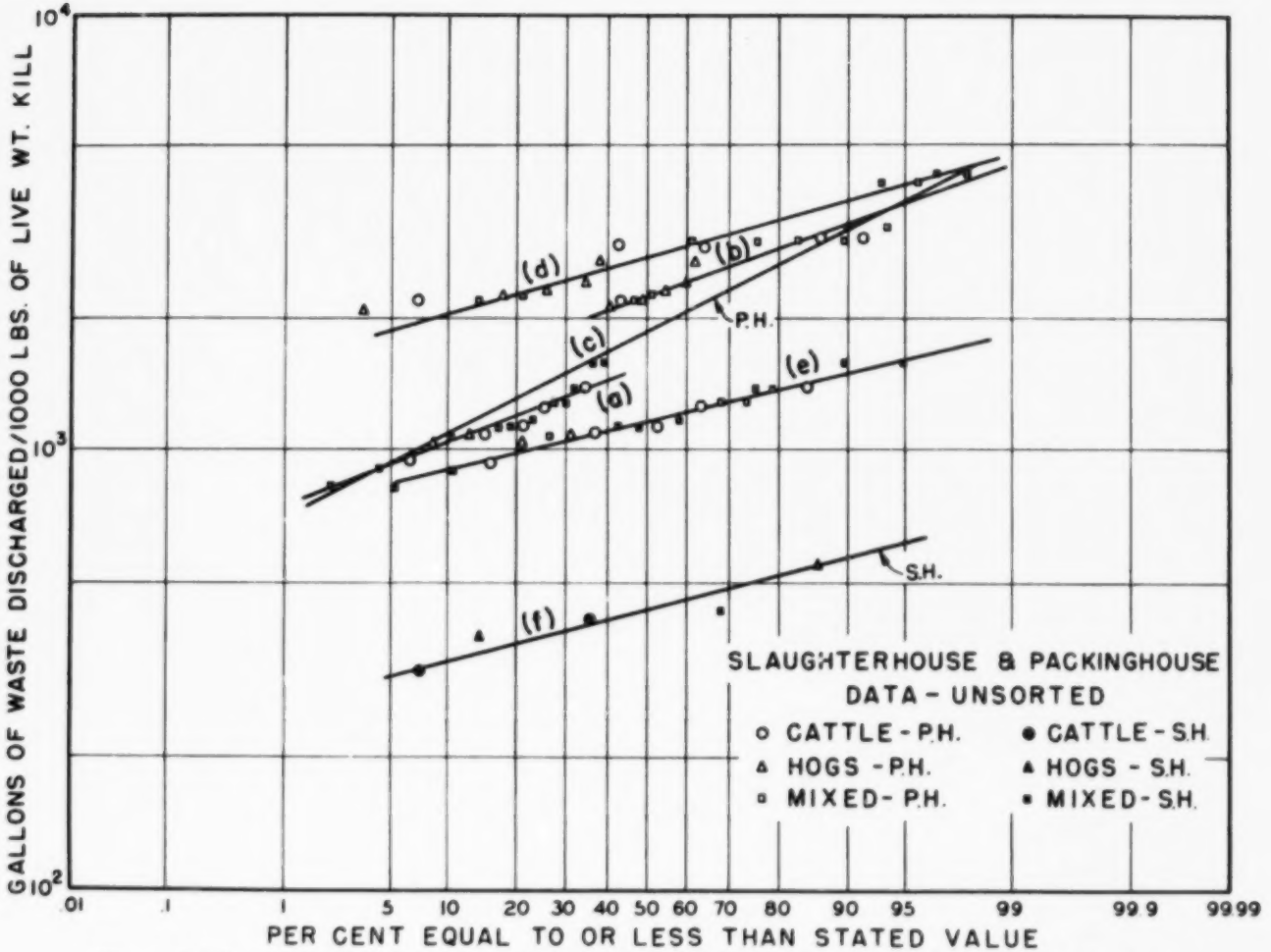

Figure 2 - Log probability plot of gallons of waste discharge/1,000 lbs of live weight kill. Curve (a) and (b) represent plot of packing house data showing break in alignment of data. Curve (c) represents line of best fit covering both curves (a) and (b). Curve (d) is a replot of curve (b) and curve (e) a replot of curve (a) assuming separate distributions. Curve (f) shows the distribution of the slaughterhouse values.

logarithmic mean value (M_g) of about 1,160 gal/1,000 lbs. LWK, and the upper group, represented by curve (d), of about 2,750 gal/1,000 lbs. LWK. The logarithmic standard deviation (s_g) for curve (d) was found to be 1.269 and for curve (e), 1.217. In this same figure, the very meager data (curve (f)) available on waste flows from slaughterhouses have been plotted, and a trend toward logarithmic normality is indicated. In this case, the M_g value was 438 gal/1,000 lbs. LWK with an s_g of 1.238. It will be noted that the variability in all three cases is somewhat similar as indicated by the slopes of the various distributions (curves (d), (e), and (f)).

To further subdivide the data, the packing house values were arrayed according to the type of kill, i.e., whether cattle, hogs, or mixed kill took place. Plots of these are shown in Figure 3, but since they represent so few individual values, it would be undesirable to draw positive conclusions therefrom. The indications are, however, that the lowest volumes of waste per 1,000 pounds of live weight kill resulted from cattle slaughter (M_g = 1,620 gal/1,000 lbs. LWK, s_g = 1.638), mixed kill was next (M_g = 1,820, s_g = 1.636), and highest with hog kill (M_g = 2,300, s_g = 1.142).

The bimodal distribution indicated for the packing house waste volume data in Figure 2 is not apparent in the replot of the packing house waste volume data in Figure 3, but this is due primarily to the fact that straight lines were drawn approximating best fit, whereas such may not necessarily have been the case. An examination of the plotted points for cattle and hogs and the resultant curves will bring this out somewhat more forcibly, since these could just as easily have been indicated by discontinuous curves. This situation can be resolved by an examination of more data or by a more careful study of the individual plant practices represented by each of the points plotted.

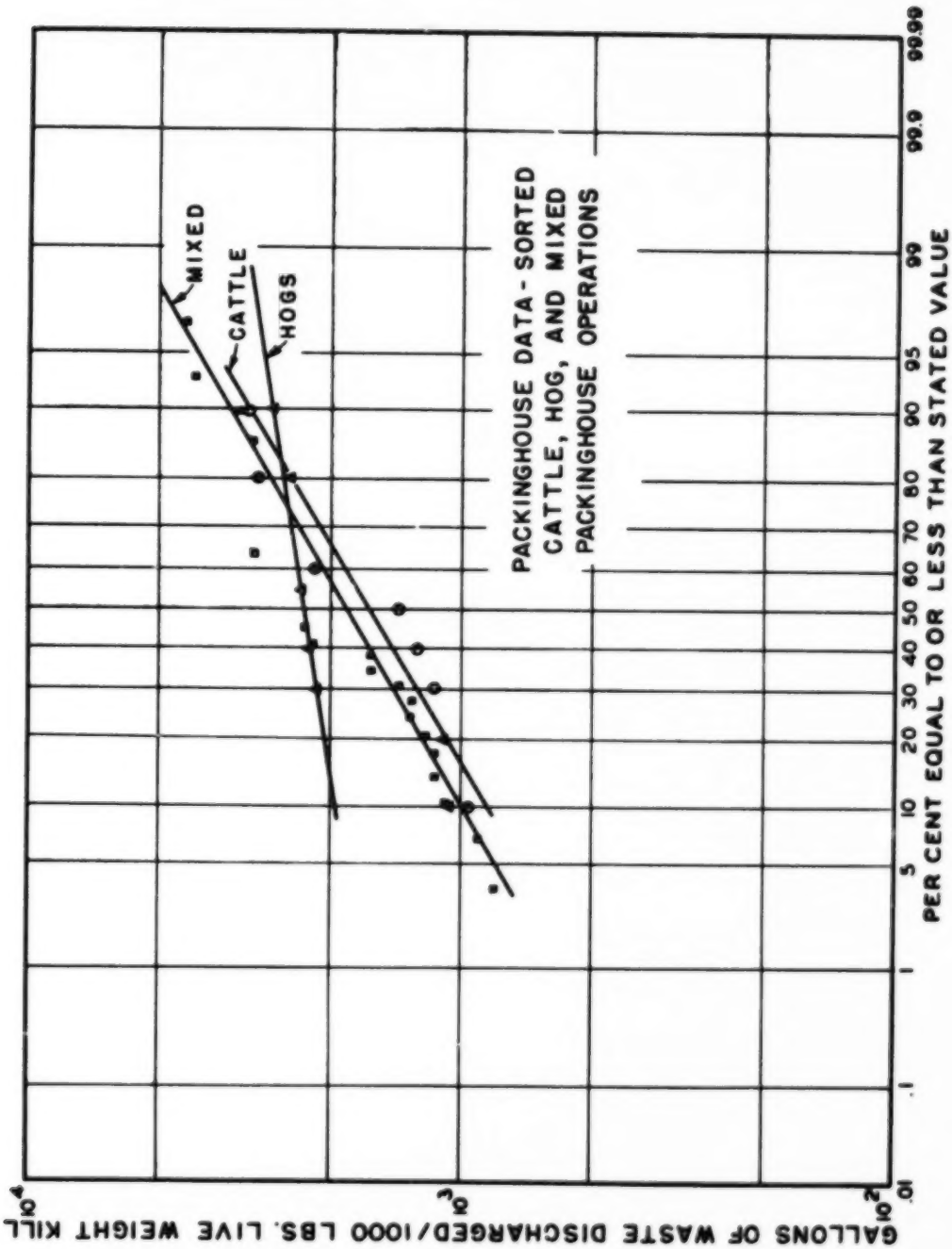

Figure 3 - Replot of packing house data in Figure 2 on the basis of kind of slaughter.

A similar analysis of Hill's Austin data[9] was made with the results shown in Figures 4 and 5. In Figure 4, all data (monthly averages) for the period January, 1941, through March, 1944, were arrayed in ascending order and plotted. The indicated values were M_g = 918 gal/1,000 lbs. LWK and s_g = 1.25. The monthly values by years were then replotted in Figure 5 and it will be seen that there was a continuous reduction in waste volume in each year from 1941 through 1943. Applying Student's "t" test for significance between the logarithmic mean values and the geometric standard deviations, it was found that the reduction in volume per unit of kill between the 1941 and 1942 values was very significant at the one per cent probability level, and that the further reduction indicated by the 1943 data was not significant when compared with the 1942 results.

Analytical Laboratory Data

Similar statistical analyses were made of the reported analytical data, such as BOD (5-day, 20° C.), SS, total nitrogen, grease, and population equivalent on BOD and SS bases.

In Figure 6, all of the BOD data have been arrayed in order of magnitude and plotted on log probability paper. Two curves are shown, the upper determined when all unsorted data* were plotted, and the lower curve which fits the plotted points. Three high BOD values (9,489, 16,750, and 21,810 ppm) were omitted in the plot of the lower curve since they represented the results of practices in very small slaughterhouses with

*See earlier footnote.

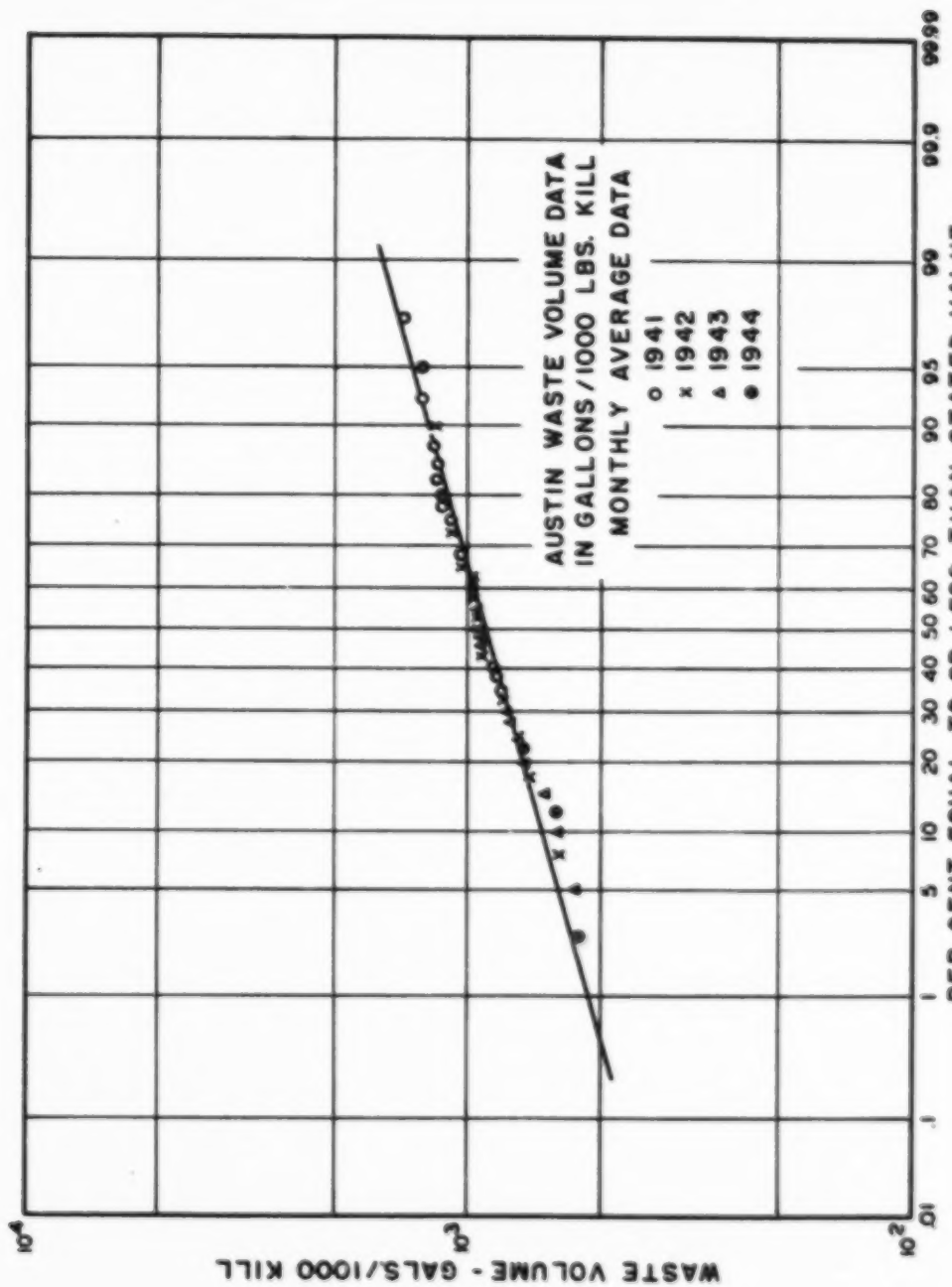

Figure 4 - Average monthly packing house waste volume data - Austin, Minnesota plant. Each point represents the average of data obtained during each month of the particular year as denoted by the given symbol.

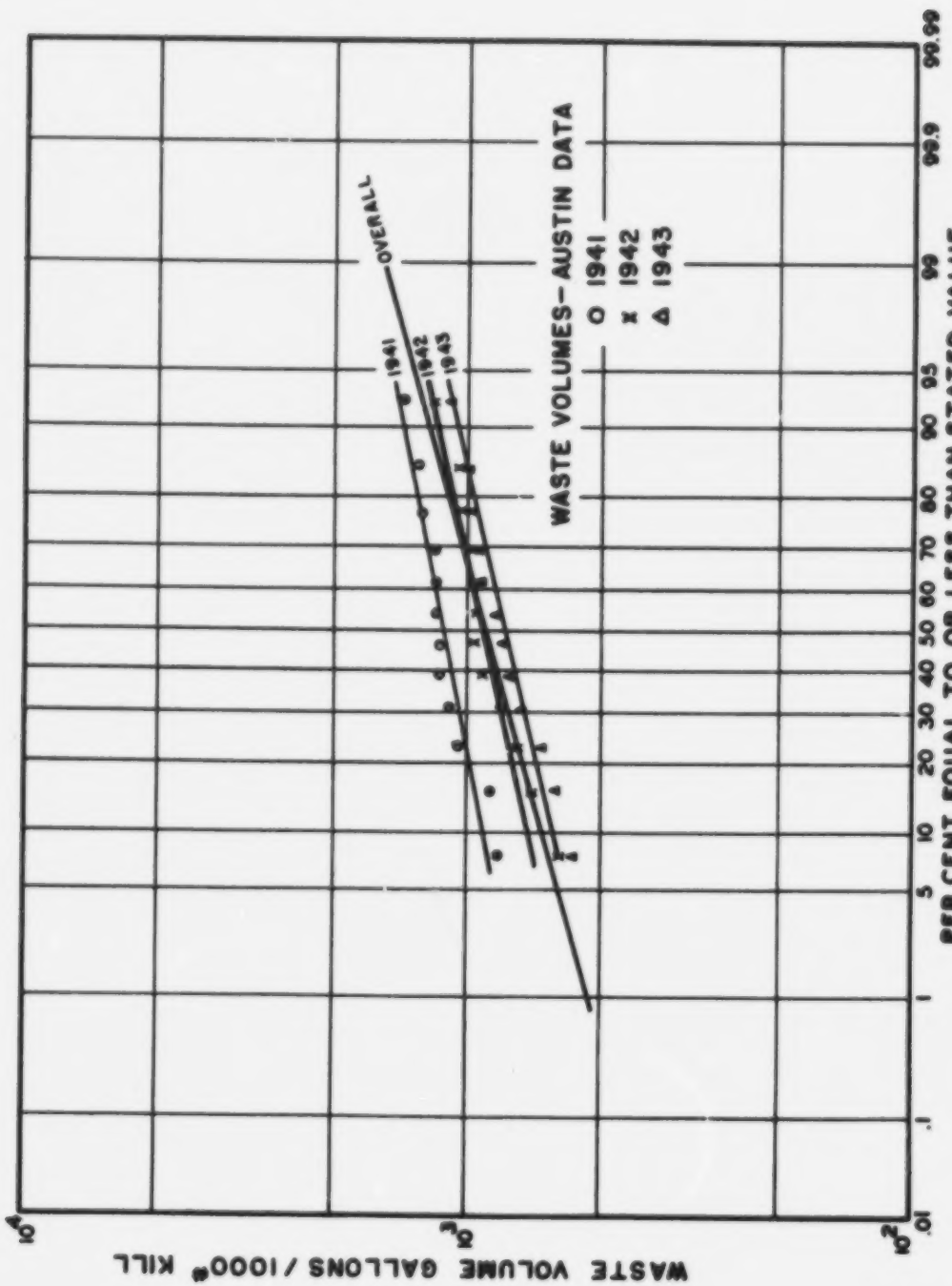

Figure 5 - Replot of Figure 4 indicating variation in waste volume data for each year as represented by monthly average data.

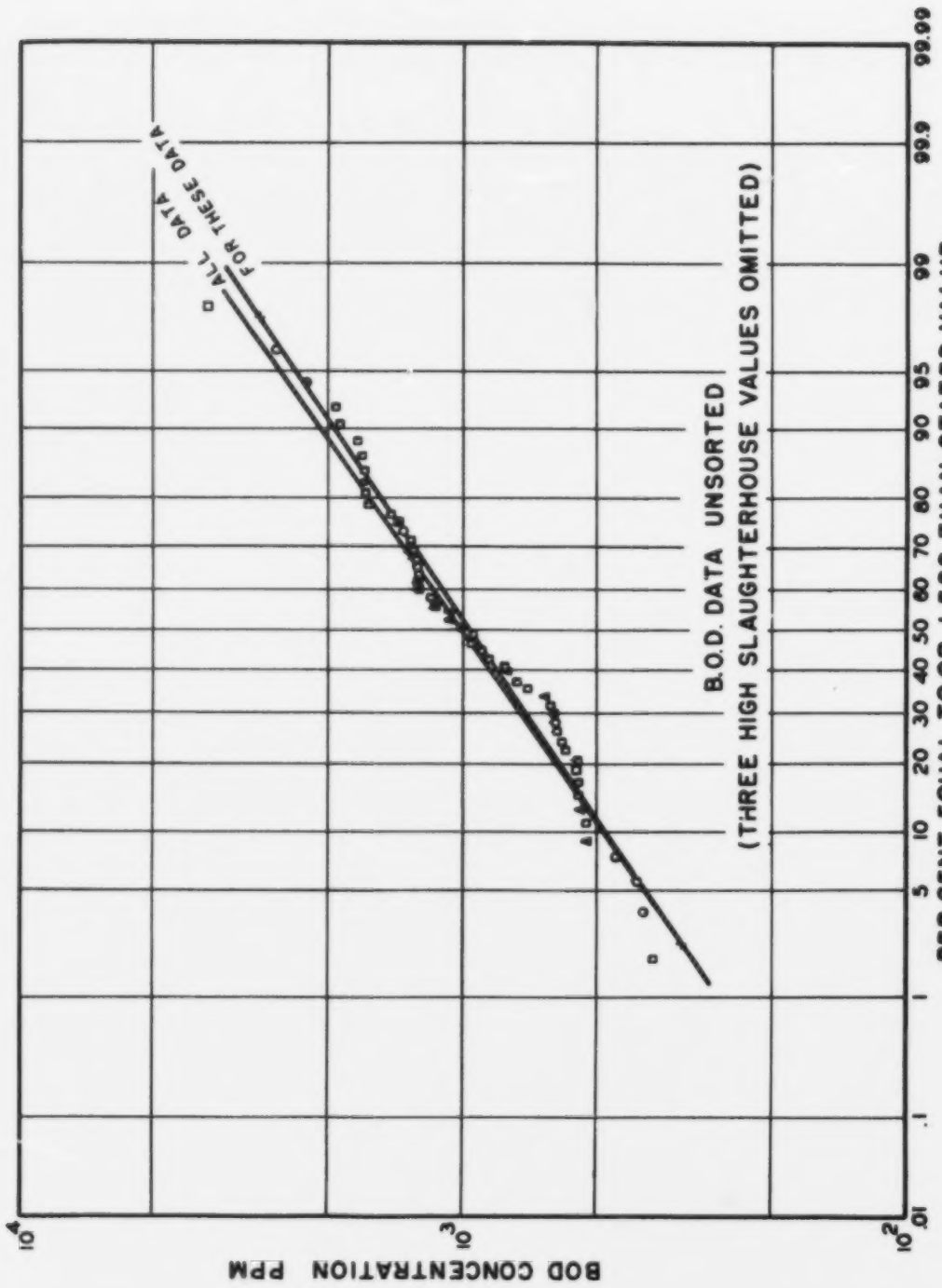

Figure 6 - Log probability plot of packing house and slaughterhouse BOD data.

waste volumes of 307 to 7,180 gpd. If the lower curve is considered, the logarithmic mean 5-day BOD is found to be 955 ppm and the s_g 1.73, giving a range of values to be expected 68 per cent of the time (M_g x or ÷ by one s_g) of 500 to 1,650 ppm or a range of 319 to 2,870 ppm if 95 per cent of the curve is considered.*

The reported 5-day BOD data have been replotted in Figure 7 in accordance with the animal processed or slaughtered. Since the number of values are somewhat limited, specific conclusions should not be drawn from these curves. However, it is quite obvious from the data included that the BOD of wastes discharged from slaughterhouses is somewhat higher than that from packing houses, that mixed packing house wastes have a higher logarithmic mean BOD than do either the hog or cattle packing house wastes considered alone, and that there seems to be considerably greater variability in the case of the cattle BOD data than for either the hog or mixed kill BOD data. The least variability is exhibited by the slaughterhouse values.

In the case of the SS data plotted in Figure 8, curve (a)(b) is discontinuous, with the first portion (a) being somewhat normal to about 825 ppm and then breaking and continuing again (b) but at an increased slope. As in the case of the waste volume data, the two curves were treated separately. It will be seen that both portions are somewhat normal with the upper curve (curve (c)) showing considerably greater variability. It would be worthwhile to

---

* The 95 per cent values are found by multiplying or dividing the M_g value by s_g^2. This relationship is analogous to the arithmetic mean plus or minus twice the standard deviation and can be so represented if the logarithms of the mean value and the standard deviation are used. In that case, one would record the log $M_g \pm 2 \log s_g$, and the values found are identical with the 95 per cent values given above.

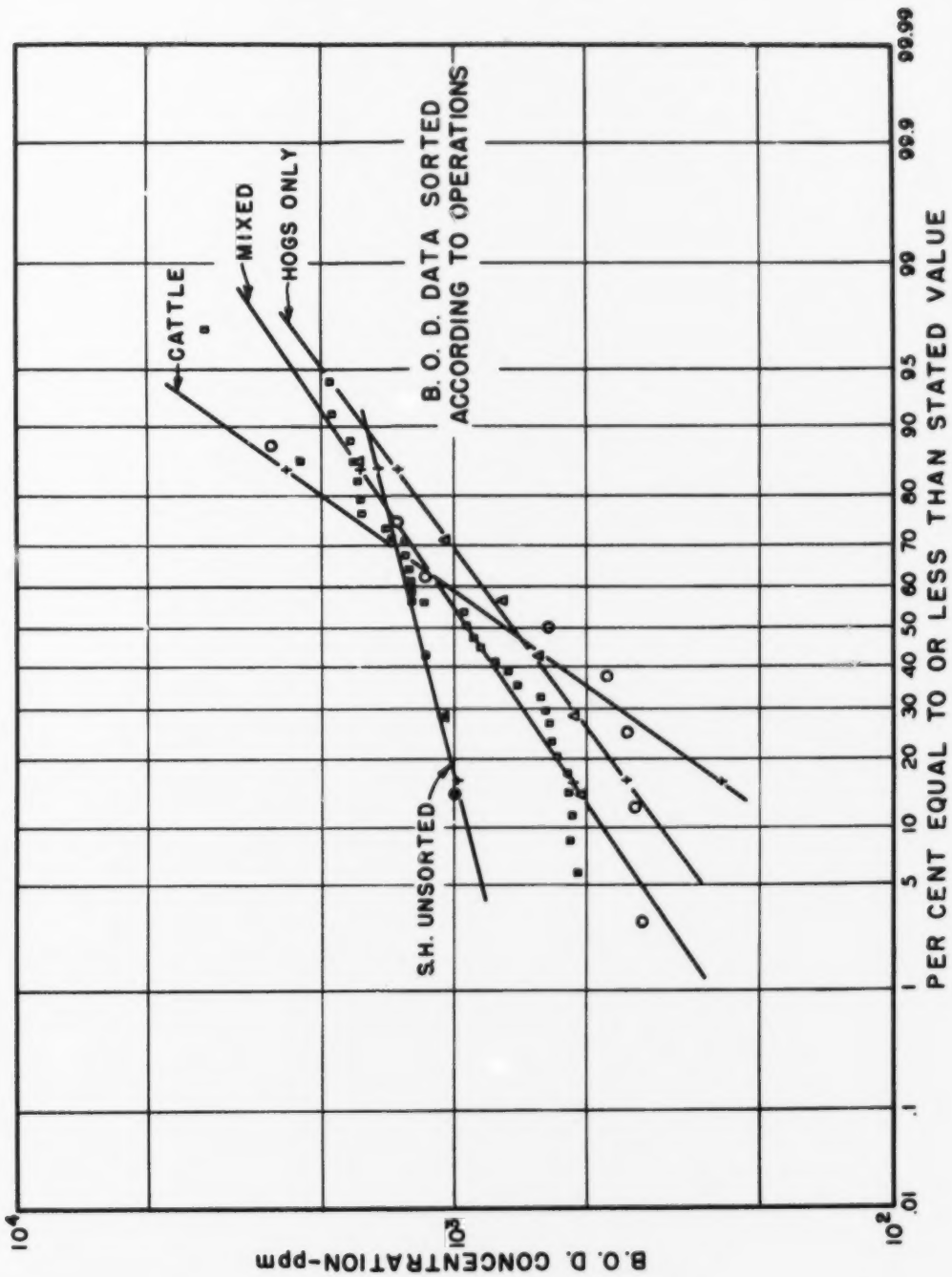

Figure 7 - Replot of Figure 6 data to show variation in BOD data as a function of type of kill.

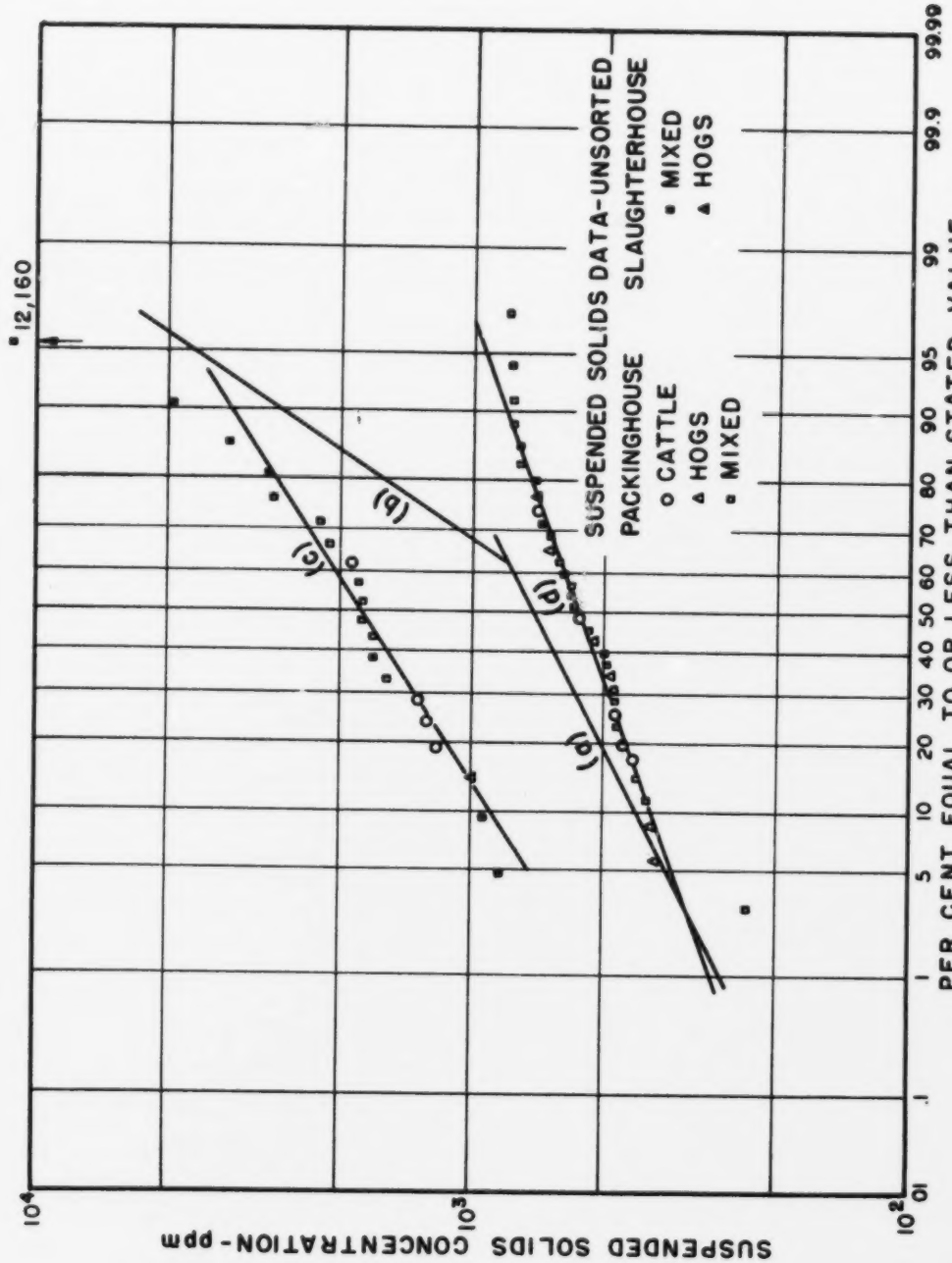

Figure 8 - Log probability plot of suspended solids data. Curve (a-b) represents plot of data as is. Portion (a) has been replotted as a separate distribution with resultant curve (d). The same has been done with (c) from (b).

reconsider the data and find out whether there is any common factor which could be identified as causing this separation. A breakdown of the data according to type of kill is given in Figure 9. On the basis of the mixed kill data shown, a distinct division occurs with a lower portion being normal below 820 ppm and an upper portion being somewhat normal above 1,300 ppm. The limited data given for slaughterhouse operations and for cattle and hog processing have been represented as logarithmically normal curves. These indicate that slaughterhouse values are highest in SS, mixed slaughter next, followed closely by cattle packing house data, and the lowest SS concentration was found in the case of hogs. (The comments made earlier relative to the biomodal characteristics of Figures 2 and 3 apply equally well to Figures 8 and 9).

Figures 10 and 11 show probability plots of the reported nitrogen values, with Figure 10 giving a plot of the heterogeneous data, and Figure 11 the same according to process. Too few results are available in the literature for these to be particularly meaningful. The limited reported grease data are shown in Figure 12. Again, it is seen that these appear to be logarithmically normal.

To calculate the population equivalent (PE) one must have knowledge of the waste volume as well as the BOD or SS concentration or the BOD and SS load in pounds. These quantities are divided by the daily per capita loadings of BOD or SS in sewage, which were taken as 0.167 pounds of BOD/capita/day and 0.20 pounds of SS/capita/day, respectively. In Figure 13, the PE in persons per ton of kill on a BOD and SS basis have been arrayed in order of magnitude and plotted on log probability paper. A straight line of best fit was then drawn through the plotted points. The M_{gBOD} PE is read off the

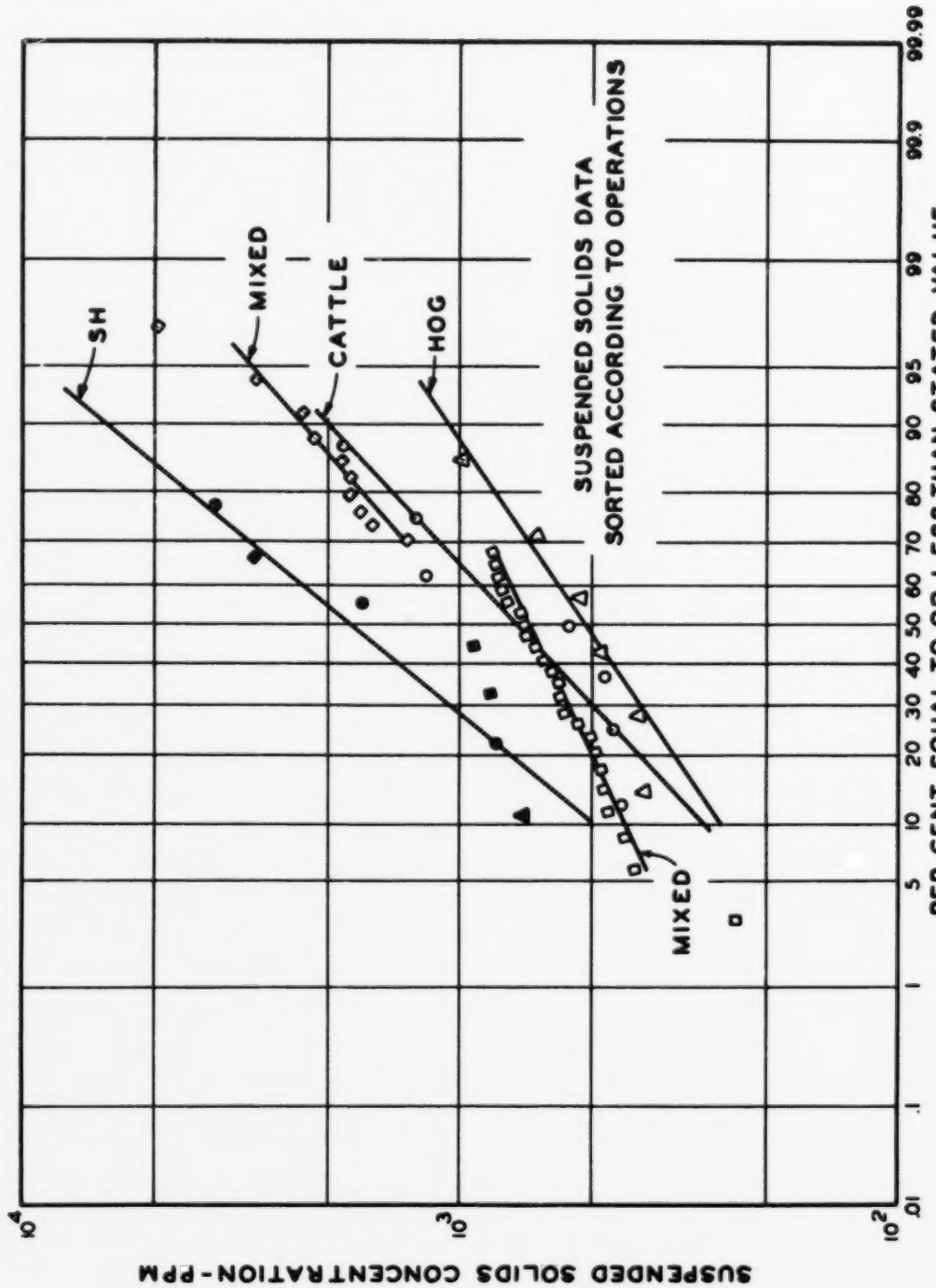

Figure 9 - Replot of Figure 8 data in accordance with type of kill.

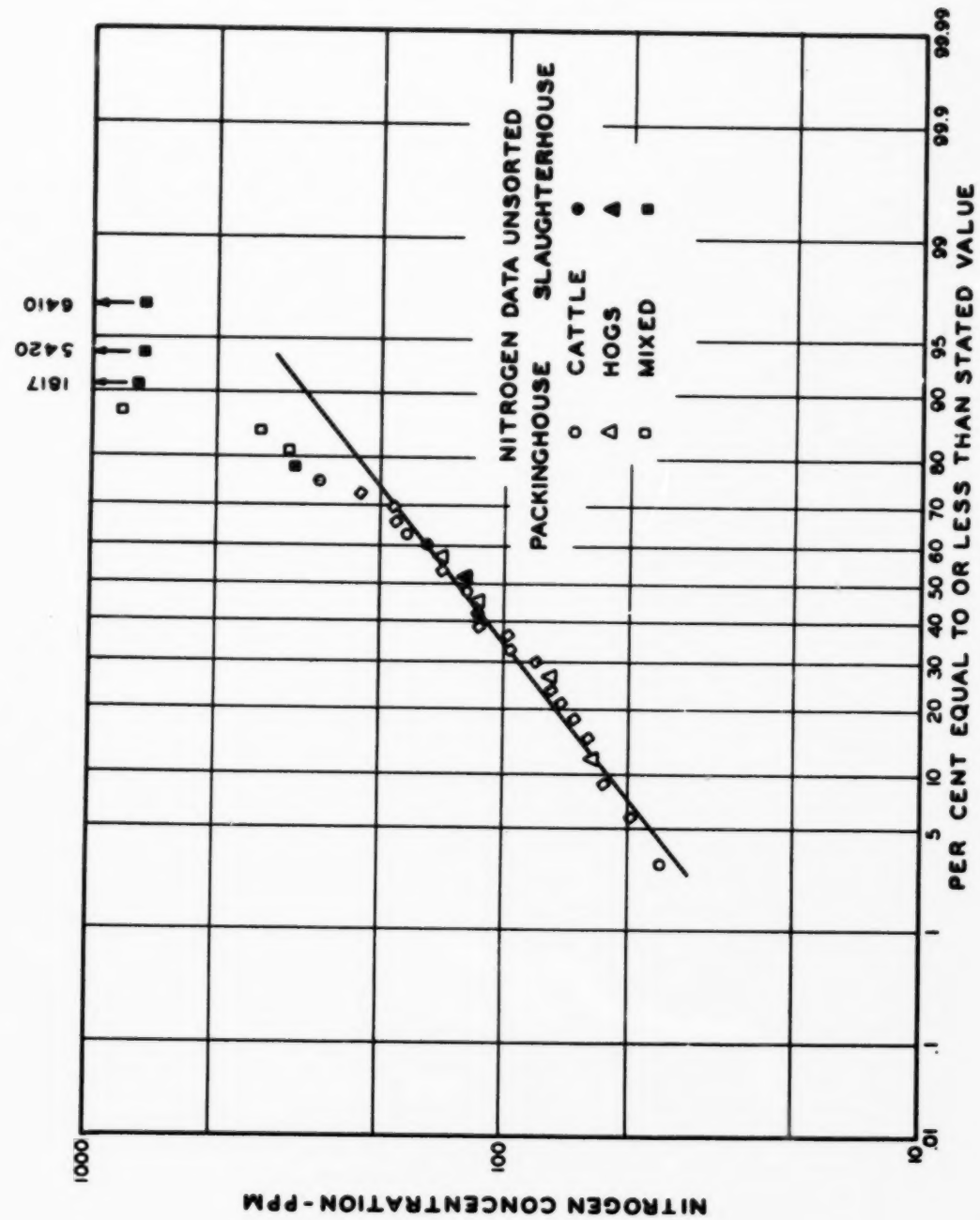

Figure 10 - Log probability plot of nitrogen data.
Unsorted with respect to type of kill.

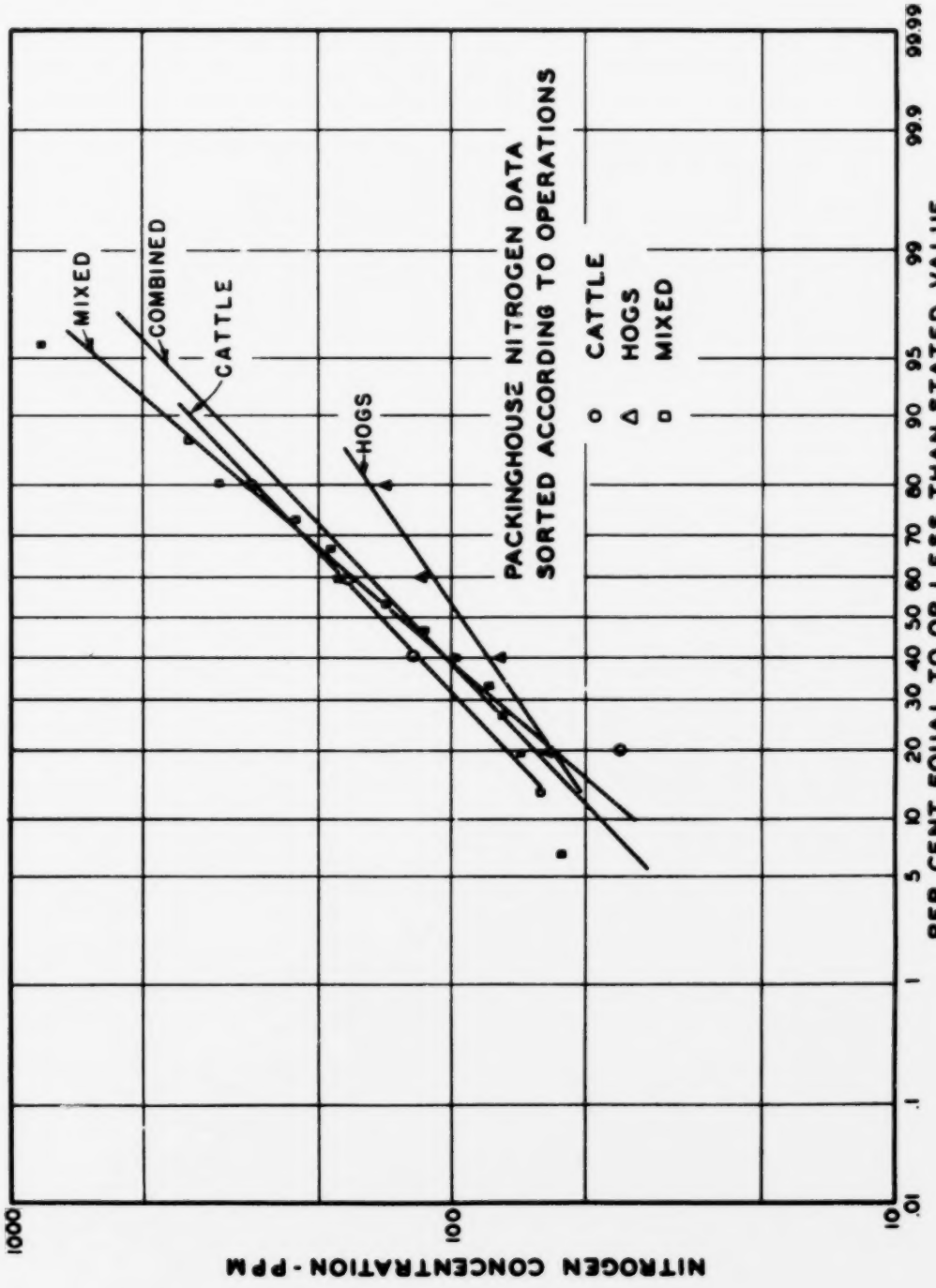

Figure 11 - Replot of Figure 10 data according to type of kill.

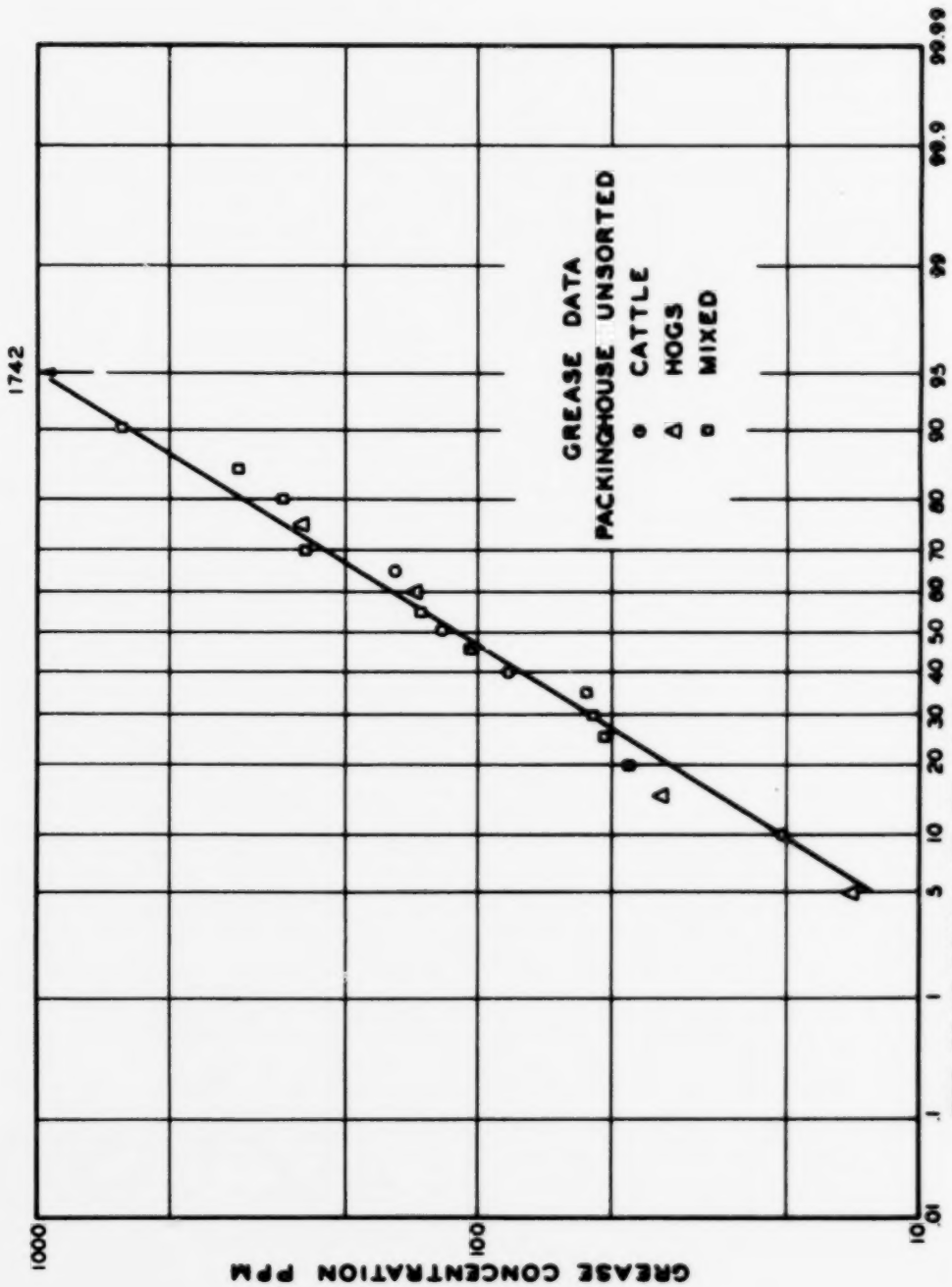

Figure 12 - Log probability plot of grease data. Unsorted with respect to packing house operations.

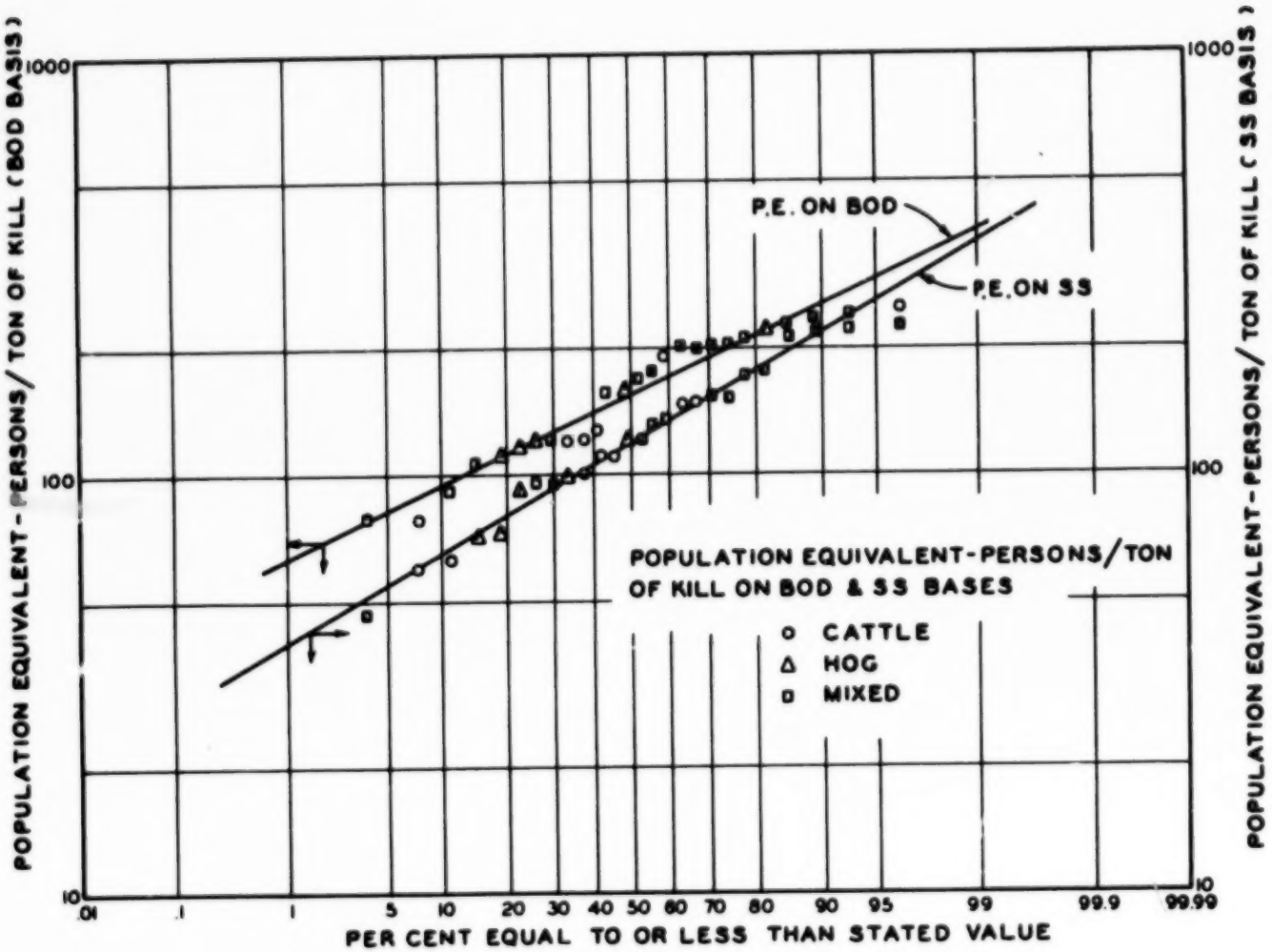

Figure 13 - Log probability plot of population equivalent on the basis of persons per ton of kill on the basis of BOD or SS data. The upper curve represents persons per ton of kill on the basis of BOD concentration and the lower curve on the basis of SS concentration.

curve and found to be 154 persons/ton of kill (BOD basis) with an s_{gBOD} of 1.484. The range corresponding to the $M_{gBOD} \overset{x}{\div} s_{gBOD}$ (68 per cent of the values included) was 104 to 229 persons/ton of kill, and for the $M_{gBOD} \overset{x}{\div} (s_{gBOD})^2$ (95 per cent of the values included) it was 72 to 340 persons/ton of kill. Values of persons/ton of kill on the SS basis were as follows: M_{gSS} = 119 persons/ton of kill, s_{gSS} = 1.606, $M_{gSS} \overset{x}{\div} s_{gSS}$ = 74 to 191, and $M_{gSS} \overset{x}{\div} (s_{gSS})^2$ = 46 to 306 persons/ton of kill.

The most probable value of PE may be calculated from the logarithmic mean BOD and SS concentration and waste volume. The values found on the basis of BOD were: Packing house unsorted 170 persons/ton of kill, packing house cattle alone 124, packing house hogs alone 170, and slaughterhouse unsorted 53. On the basis of SS these values were: Packing house unsorted 126 persons, packing house cattle alone 119, packing house hogs alone 119, and slaughterhouse unsorted 77.5.

Single Plant Analytical Data

Some years ago Mohlman[10] presented data summarizing load discharges from fourteen Chicago plants. These data have been plotted in Figure 14 along with Hill's Austin values[9] reported for 1941-1943. Even though these data are not comparable in themselves, they were compared to determine whether a significant difference existed between the two series. By application of Student's "t" test a high significant difference was found between the two series of data. This finding was not too surprising inasmuch as the Austin results represent pre-treated waste loadings whereas the Chicago values are BOD loadings of the raw waste. The Austin wastes are chlorinated and settled before discharge to the municipal sewerage system.

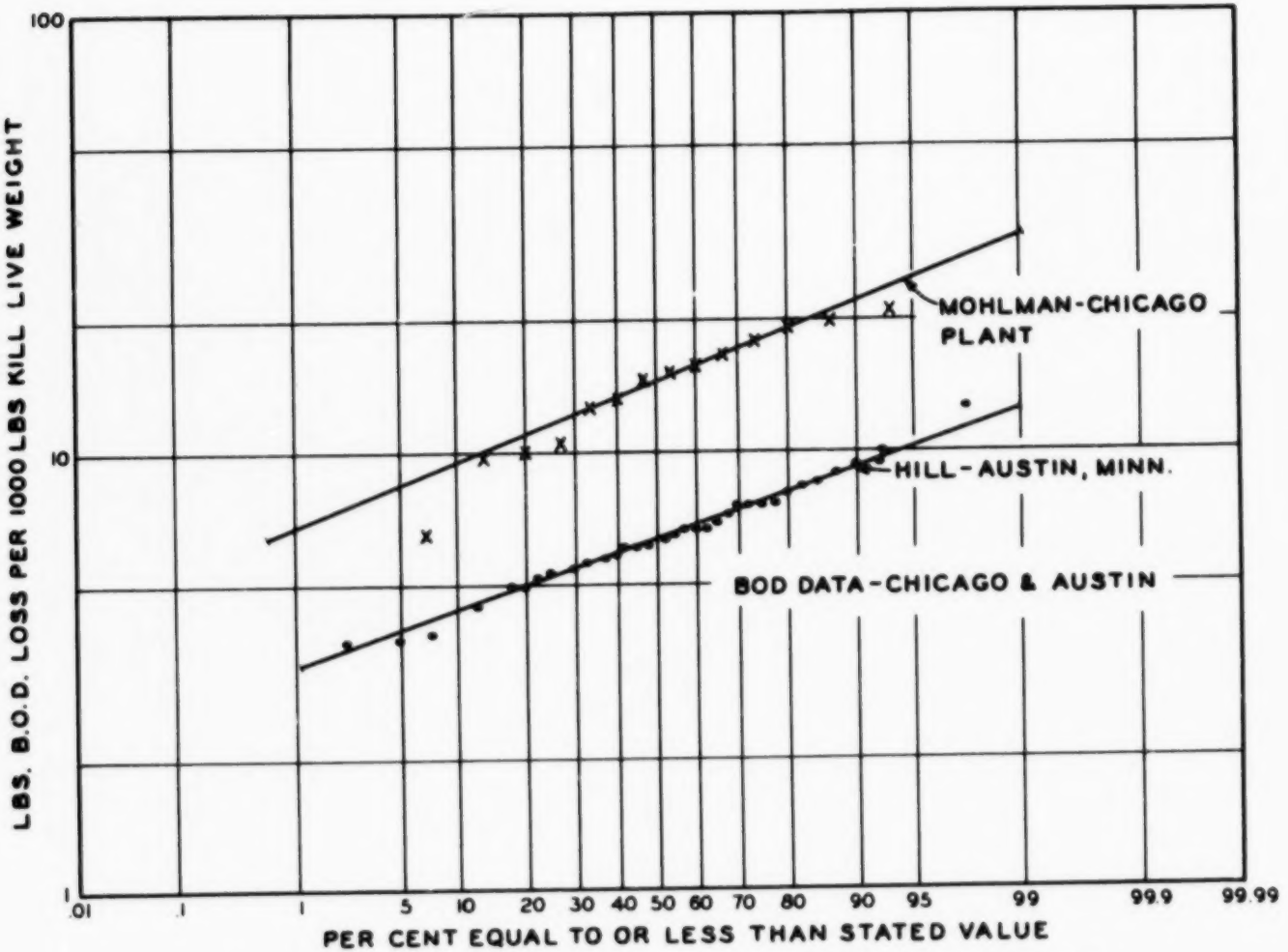

Figure 14 - Log probability plots showing pounds of BOD loss per 1,000 pounds live weight kill reported by Mohlman for 14 Chicago plants as compared with Hill's Austin, Minnesota data. Chicago plant data based on raw wastes, Austin data on pretreated wastes.

Monthly waste loadings reported by Hill for Austin and plotted in Figure 15 were compared for significant differences on an annual basis by means of Student's "t" test. It was found that the difference between the 1941 and 1942 distributions was not significant, but that the difference between the 1942 and 1943 values was very significant. A comparison of the 1941 and 1943 data indicated that the difference was barely significant at the one per cent probability level. The suspended solids loadings for the Austin plant are shown in Figure 16. No significant difference exists between these distributions.

Conclusion

By means of the graphical and analytical statistical procedures employed, it has been possible to determine mean values for many of the packing house waste parameters, to show the variation in the data, to indicate that, in general, log probability plots of these data were normal, and to compare data to determine the significance of their differences.

The analytical procedures employed bring out the fact that packing house and slaughterhouse data, particularly when they are compared without reference to particular plants, may be highly variable. This results from the variability in plant killing and recovery practices, numbers and kinds of animals slaughtered, and waste collection or treatment facilities available, etc. The average values reported may be somewhat at variance with values reported in guides, etc., which generally were obtained from the critical evaluation of wastes produced by a single plant employing a particular process as compared with the heterogeneous data evaluated herein.

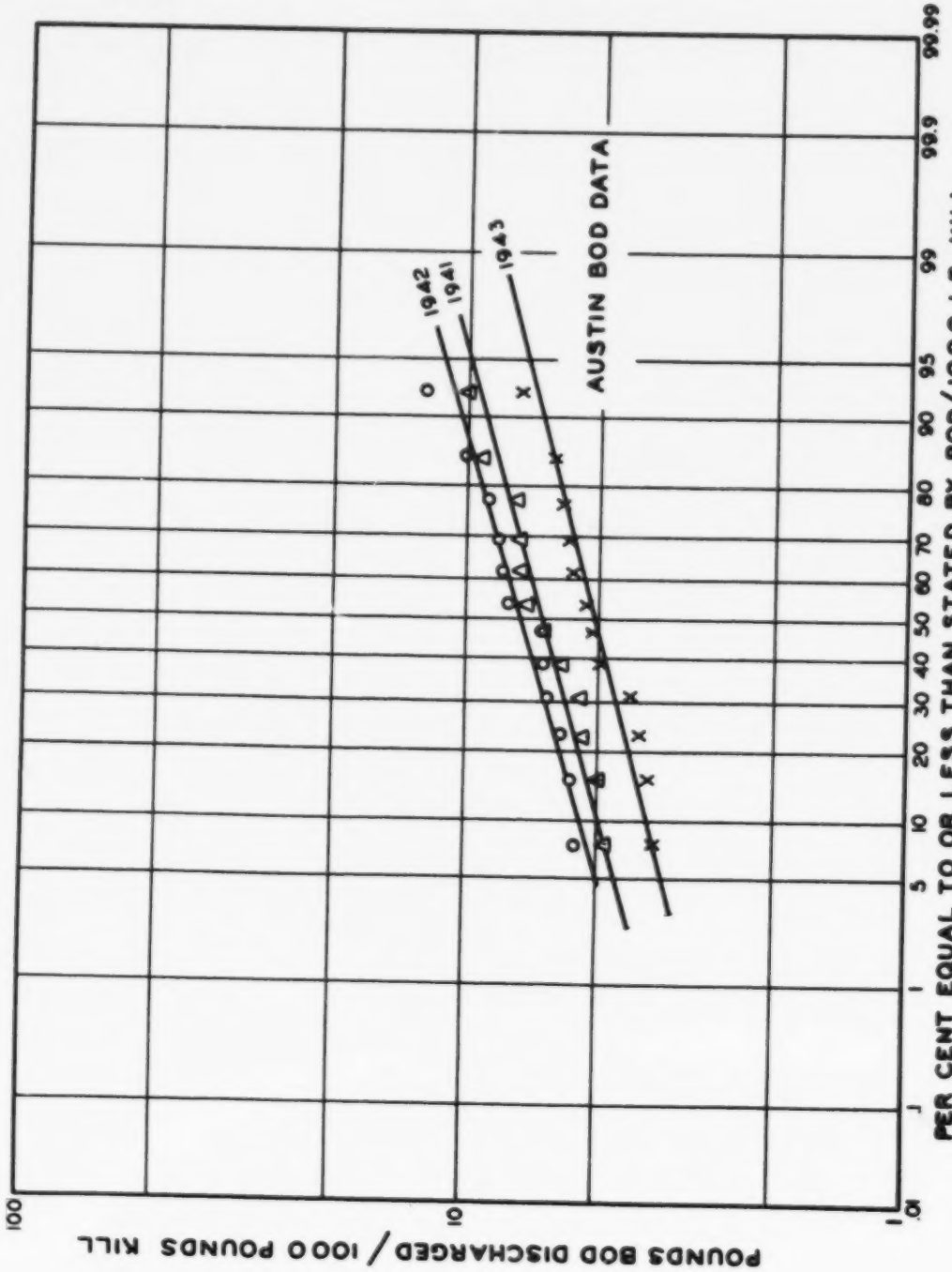
AUSTIN BOD DATA
1942
1941
1943
PER CENT EQUAL TO OR LESS THAN STATED BY BOD/1000 L.B. KILL
POUNDS BOD DISCHARGED / 1000 POUNDS KILL

Figure 15 - Log probability plot of pounds BOD loss per 1,000 pounds live weight kill by months for 1941, 1942, and 1943 at Austin, Minnesota.

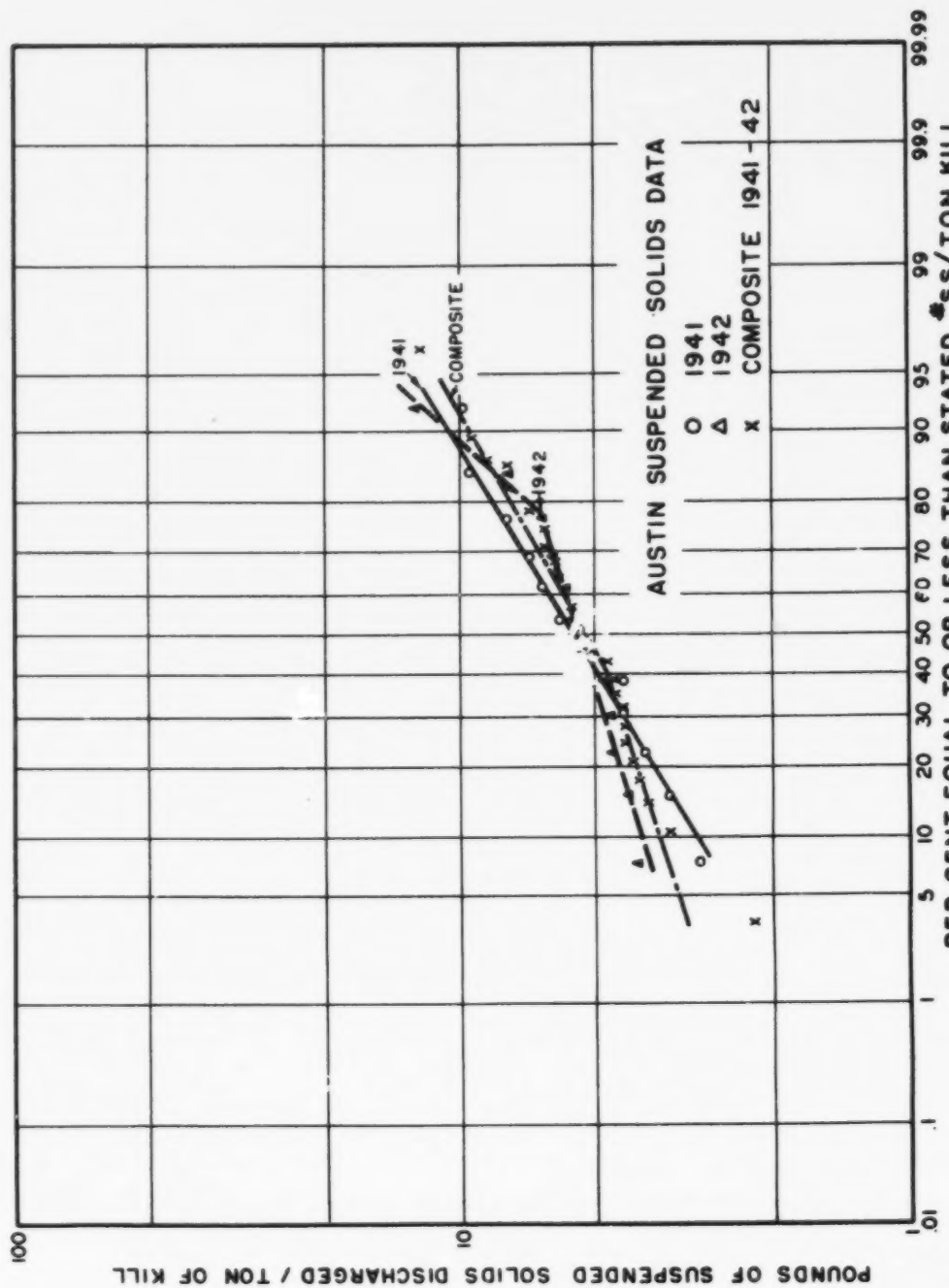

Figure 16 - Log probability plot of pounds suspended solids discharged per ton of kill by months for 1941 and 1942. A plot is also given of the composite data for 1941-1942.

To permit a better evaluation of these parameters more complete reporting of analytical results is a necessary prerequisite. It is the writer's opinion that at least the following should be reported: A mean value (M or M_g); the standard deviation (s or s_g), or if this is impossible then the range in values; the number of tests or analyses made (n); the type and kind of slaughter; the size of the killing floor or processing floor in terms of area; the actual volumes of water used in terms of floor wash per unit of area and animal wash per unit weight of slaughter or material processed; etc. Too much data can never be reported.

As our fund of data increases, the analyses outlined herein will gain in stature, and the parameters gleaned from them will be more reliable. If similar trends can be shown for many installations discharging similar wastes, the establishment of operating norms which may be used by the industry in a manner similar to production control data will be possible. With sufficient knowledge about the characteristics of the receiving stream and the waste materials being discharged, unit loss criteria may be evaluated for any given plant, recognizing that a certain amount of variability will occur. Such knowledge will permit the establishment of more realistic criteria for the various wastes encountered, and these should be understood by management, since the approach used in their evaluation is identical with that used in product quality control.

Finally, it must be remembered that statistical methods cannot replace judgment and experience, but given a chance, their use will permit a more intelligent appraisal of the factors involved.

REFERENCES

1. Peters, Clarence C., and Van Voorhis, Walter R., Statistical Procedures and Their Mathematical Bases , Page 40, McGraw-Hill Book Company, Inc., New York, New York, (1940).

2. Fair, Gordon M., "Mathematical Aspects of Sewage Research", in Modern Sewage Disposal, Federation of Sewage Works Association, New York, New York, (1938).

3. Velz, C.J., "Graphical Approach to Statistics", Water and Sewage Works, 99:4, R-106 (April, 1952).

4. Weston, Roy F., Merman, Robert G., and DeMann, Joseph G., "Coagulation of Refinery Wastes by Twin Pilot-Plant Units", Proceedings, 4th Industrial Waste Conference, Purdue University, Lafayette, Indiana, Page 290 (September 21-22, 1948).

5. Weston, Roy F., Merman, Robert G., and DeMann, Joseph G., "The Industrial Plant Waste Disposal Survey", Sewage Works Journal, 21:2, 274 (March, 1949).

6. Dougherty, R.J., "The Treatment of Food Processing Wastes", Proceedings, 6th Industrial Waste Conference, Purdue University, Lafayette, Indiana, Page 479 (February 21-23, 1951).

7. Eckenfelder, W. Wesley, Jr., "Pilot Plant Investigations of Biological Sludge Treatment of Cannery and Related Wastes", Proceedings, 7th Industrial Waste Conference, Purdue University, Lafayette, Indiana, Page 181 (May 7-9, 1952).

8. Thomas, Harold A., Jr., "Frequency of Minor Floods", Journal, Boston Society of Civil Engineers, 35: 425 (1948).

9. Hill, Kenneth V., "Treatment of Packing House Wastes", Sewage Works Journal, 17:2, 292 (March, 1945).

10. Mohlman, F.W., "Packing House Industry", Ind. Engr. Chem., 39: 637 (May, 1947).

11. Stiemke, Robert E., "Disposal of Wastes from Small Abattoirs", Proceedings, 4th Industrial Waste Conference, Purdue University, Lafayette, Indiana, Page 178 (September 21-22, 1948).

12. U.S. Public Health Service, Ohio River Pollution Control, Supplement to Part II, "An Industrial Waste Guide to the Meat Industry", Page 1, 139 U.S. Govt. Printing Office, Washington, D.C., (1944).

13. Mohlman, F.W., "Possibilities of Recovery and Utilization of Industrial Wastes", Transactions, American Society of Civil Engineers, 114:338 (1948).

14. Anon. Slaughterhouse Waste Treatment Guide, West Virginia Water Commission, 20 pp., (November 15, 1946).

15. Jones, E.E., "Waste Waters Discharged from an Abattoir", The Surveyor, 107:159 (March 26, 1948).

16. Anon. Meat Packing and Slaughterhouse Wastes in Texas. Public Works, 72:19 (April, 1941).

17. Mohlman, F.W., "Utilization and Disposal of Industrial Wastes", Proceedings, 1st Industrial Waste Utilization Conference, Purdue University, Lafayette, Indiana, (Page 43, 1944).

18. Mahlie, W.J., "Industrial Waste Pre-Treatment at Fort Worth, Texas", Sewage Works J., 15:521 (1943).

19. Eldridge, E.F., "Meat Packing Waste Disposal", Michigan Engr. Expt. Sta., Bull. 105 (December, 1946).

20. Merryfield, Fred, "Industrial Wastes in the Willamette Valley", Civil Engr., 6:682 (1936).

21. Mohlman, F.W., "The Disposal of Industrial Wastes", Sewage Works J., 11:4, 646 (July, 1939).

22. Mohlman, F.W., "Treatment of Packing House, Tannery and Corn Products Wastes", Ind. Engr. Chem., 18:1076 (1926).

*References 11-22 are those from which data were taken and which have not been mentioned in the text proper.

APPENDIX "A"

SUMMARY OF WASTE VOLUME DATA

Plant Number	Type of Plant	Type of Kill	No. of Plants	Volume of Waste gal/1000 # LWK	Unsorted		Dividing at about 2000 gal/1000# LWK		Cattle Alone		Hogs Alone		Mixed Kill Alone		Reference Number
					Rank	Plotted Position %	Rank	Plotted Position %	Rank	Plotted Position %	Rank	Plotted Position %	Rank	Plotted Position	
1	SH	C	1	316	1	7.15									11
2	SH	H	1	385	2	14.3									11
3	SH	C	6	416	5	35.7									12
4	SH	M	3	434	9 1/2	67.9									12
5	SH	H	2	550	12	85.8									12
1	PH	M	1	835	1	2.13	1	5.26					1	3.45	9 A-3
2	PH	M	1	916	2	4.26	2	10.53					2	6.90	9 A-2
3	PH	C	1	950	3	6.39	3	15.8	1	10					13
4	PH	H	1	1045	4	8.51	4	21.05			1	10			14
5	PH	M	1	1090	5	10.66	5	26.3					3	10.36	9 C
6	PH	H	1	1100	6	12.79	6	31.6			2	20			13
7	PH	C	1	1100	7	14.9	7	36.8	2	20					13
8	PH	M	1	1130	8	17.04	8	42.1					4	13.8	9 A-1
9	PH	M	1	1130	9	19.18	9	47.3					5	17.25	14
10	PH	C	1	1130	10	21.3	10	52.6	3	30					14
11	PH	M	1	1190	11	23.4	11	58.0					6	20.7	14
12	PH	C	1	1270	12	25.5	12	63.2	4	40					9 I
13	PH	M	1	1300	13	27.7	13	68.5					7	24.1	13
14	PH	M	1	1300	14	29.8	14	73.8					8	27.6	13
15	PH	M	1	1400	15	31.9	15	79.0					9	31.0	13
16	PH	C	1	1400	16	34.05	16	84.3	5	50					13
17	PH	M	1	1600	17	36.2	17	89.5					10	34.5	9 B
18	PH	M	1	1600	18	38.3	18	94.8					11	38.0	9 D
19	PH	H	1	2150	19	40.4	1	3.45			3	30			9 H
20	PH	C	2	2202	20	42.5	2	6.90	6	60					12
21	PH	M	1	2210	22	46.8	4	13.8					12	41.4	9 G
22	PH	H	1	2250	23	49.0	5	17.25			4	40			13
23	PH	M	1	2300	24	51.1	6	20.7					13	44.8	13
24	PH	H	3	2348	25 1/2	54.2	7 1/2	25.85			5 1/2	55			12
25	PH	H	1	2450	28	59.6	10	34.5			8	80			13
26	PH	H	1	2750	29	61.7	11	38.0			9	90			13
27	PH	C	1	2960	30	63.8	12	41.5	8	80					9 F
28	PH	M	11	3026	35 1/2	75.5	17 1/2	60.4					18 1/2	63.8	12
29	PH	M	1	3050	42	89.4	24	82.9					25	86.3	9 E
30	PH	C	1	3100	43	91.5	25	86.3	9	90					13
31	PH	M	1	3250	44	93.6	26	89.8					26	89.8	13
32	PH	M	1	4160	45	95.7	27	93.2					27	93.2	9 J
33	PH	M	1	4350	46	97.9	28	96.7					28	96.7	13

APPENDIX "B"

SUMMARY OF DATA

Plant Number	Kill	Flow - gal/day	BOD-ppm	SS-ppm	Total N - ppm	Grease - ppm	BOD #/ton Kill	SS #/ton Kill	Total N #/ton Kill	Grease #/ton Kill	PE - BOD persons/ton Kill	PE - SS persons/ton Kill	Plant Designation	Reference No.
1A	28[a]	440	1250	1660	116		1.26	1.67	0.117		7.35	8.35	S-M	14
2B	41[a]	307	16750	3610	6410		8.03	1.73	0.308		48.1	8.16	S-M	14
3C	28.5[a]	3550	9489	2921	1827		75.8	23.3	14.6		454	117	S-M	14
4D	25[a]		21810	12160	5420								S-M	14
5	75[a]	7180	1380	855	91[f]		8.48	5.25	0.558		50.8	26.3	S-M	15
6		574000	1164										S-M	16
7			610	594	77[g]								P-M[i]	17
8			2240	929	324								S-M[i]	12
9			996	820	154								S-C[i]	12
10			1048	717	122								S-H[i]	12
11			953	699	141[g]								P-M[i]	12
12			587	398	98								P-M[i]	12
13			550	467	68								P-M	12
14			758	708									P-M	12
15			955	720									P-M	12
16			372	233									P-M	12
17			1240	534	83[g]								P-M	12
18			1634	665	181[g]								P-M	12
19A	11256[a]	2688000	1294	2232		244	19.8	34.1		3.73	119	171	P-M	18
20B	426[a]	62000	3740	4848	840[g]	1742	34.7	45.0	7.8	16.2	208	225	P-M	18
21C	70[a]	10000	1923	2885	333[g]	645	17.6	26.4	3.0	5.90	106	132	P-M	18
22D	360[a]	50000	1716	2107	389[g]	350	15.3	18.8	3.5	3.12	92	94	P-M	18
23		2189[d]	448	467									P-C	19
24		552[d]	1030	6631									P-H	19
25		996[d]	635	457	113[h]								P-M	19
26			1300	780									P-M	20
27	51[b]	5500[e]	785	523	117	39	36.0	24.0	5.34	1.80	216	120	P-H	10
28	114[b]	2200[e]	1643	994	141	252	30.1	18.2	2.58	4.61	109	91	P-H	10
29	127[b]	2600[e]	1173	420	187	133	25.4	9.1	4.05	2.88	152	46	P-M	10
30	139[b]	4900[e]	643	481	61	139	26.2	19.6	2.50	5.66	157	98	P-H	10
31	148[b]	1900[e]	2620	1870	282	85	41.5	29.6	4.47	1.35	249	148	P-C	10
32	165[b]	2800[e]	1345	1263	172	153	31.4	29.5	4.02	3.58	188	148	P-C	10
33	168[b]	2000[e]	1260	1196	122	121	21.0	19.9	2.04	2.01	126	100	P-C	10
34	185[b]	2800[e]	1689	805	222	52	39.4	18.8	5.18	1.20	236	94	P-M	10
35	190[b]	4500[e]	521	382	78	14	19.5	14.3	2.93	0.54	117	72	P-H	10
36	303[b]	4600[e]	871	780	114	104	33.4	29.9	4.37	4.00	200	150	P-M	10
37	397[b]	6200[e]	387	426	42	21	20.0	22.0	2.16	1.10	120	110	P-C	10
38	429[b]	6500[e]	543	489	63	55	29.4	26.5	3.41	3.00	176	133	P-M	10
39	661[b]	2600[e]	600	577	73	46	13.0	12.5	1.58	1.00	78	62.6	P-M	10
40	680[b]	8700[e]	526	592	57	57	38.5	44.3	4.20	4.20	231	222	P-M	10
41EF		2.79×10^8	1651	1739									P-M	9
42B	2.1×10^6[c]	4.8×10^6	1253*	1313*			33.4	35.0			200	175	P-M	9
43D	1.6×10^6[c]	2.48×10^6	1261*	1576*			33.6	42.0			202	210	P-M	9
44E	1.0×10^6[c]	3.05×10^6	551*	472*			28.0	24.0			168	120	P-M	9
45F	0.9×10^6[c]	2.71×10^6	402*	446*			19.8	22.0			119	110	P-C	9
46G	0.7×10^6[c]	1.46×10^6	902*	815*			33.2	30.0			200	150	P-M	9
47H	0.4×10^6[c]	0.93×10^6	536*	391*			19.2	14.0			115	70	P-H	9
48I	1.4×10^6[c]	1.81×10^6	614*	567*			13.0	12.0			78	60	P-C	9
49J	1.6×10^6[c]	6.54×10^6	545*	635*			37.8	44.0			227	220	P-M	9
50			621	614									P-M	21
51			717	490	49.3								P-M	22
52		3.048×10^6	1620	1806									P-M	9
53		2.65×10^6	1900	1730									P-M	9
54		2.573×10^6	1433	1682									P-M	9

a. hog units, b. tons, c. pounds, d. per animal, e. gal/ton, f. NH_3, g. organic plus ammonia, h. organic, i. average, * calculated.